

## Analysis of factors affecting performance of excavation equipment.

## Análisis de factores que afectan el rendimiento de los equipos de excavación.

Alden Christopher Rodrigues<sup>1</sup>, Amaan M. Kamarudeen<sup>1</sup>, Sangeetha A.<sup>1</sup>, Anue Mary Mathew<sup>2</sup>

<sup>1</sup>Student, Department of Civil Engineering, Toc H Institute of Science & Technology, Kerala, India.

<sup>2</sup>Assistant Professor, Department of Civil Engineering, Toc H Institute of Science & Technology, Kerala, India.

Corresponding author's email (in order): aldenrodrigues2000@gmail.com, amaankamarudeen@gmail.com, sangeethasanthosh37@gmail.com, anuemathew@tistcochin.edu.in

### ABSTRACT

Performance is a numerical measurement of the quality of an organization or process assessed through the measurement of physical products and statistical sampling of the output of processes. Excavation equipment is heavy-duty vehicles specifically created for carrying out excavation activities. Excavators and Backhoe loaders are the most common equipment's used for excavation in the construction industry. Defects or lapses in the performance of such equipment can lead to increased costs and delays in project completion. This project involves the identification of the factors that affect the quality performance of excavation equipment used for excavation in construction sites through a literature review. After the identification of these factors, a questionnaire is prepared from the factors identified and site visits are conducted to various construction sites across Ernakulam district and construction practitioners including project managers, site engineers and contractors was interviewed and the data is collected. After the collection and analysis of data, the major factors that affect the performance was ranked. The type of soil with RII value of 0.832 was ranked first indicating this factor affects the performance of excavation equipment the most and foot traffic near site of excavation RII value of 0.588 affects the performance of excavation equipment the least.

Keywords: Mobile application, Quality, Performance, Excavation, SPSS.

### RESUMEN

El desempeño es una medida numérica de la calidad de una organización o proceso evaluado mediante la medición de productos físicos y el muestreo estadístico del resultado de los procesos. Los equipos de excavación son vehículos pesados creados específicamente para realizar actividades de excavación. Las excavadoras y retroexcavadoras son los equipos más utilizados para la excavación en la industria de la construcción. Los defectos o fallas en el desempeño de dichos equipos pueden generar mayores costos y retrasos en la finalización del proyecto. Este proyecto implica la identificación de los factores que afectan el desempeño de la calidad de los equipos de excavación utilizados para la excavación en sitios de construcción a través de una revisión de la literatura. Después de la identificación de estos factores, se prepara un cuestionario a partir de los factores identificados y se realizan visitas a varios sitios de construcción en todo el distrito de Ernakulam y se entrevistó a profesionales de la construcción, incluidos gerentes de proyecto, ingenieros de sitio y contratistas, y se recopilan los datos. Después de la recopilación y

análisis de datos, se clasificaron los principales factores que afectan el desempeño. El tipo de suelo con un valor RII de 0,832 ocupó el primer lugar, lo que indica que este factor afecta más el rendimiento del equipo de excavación y el tráfico peatonal cerca del sitio de excavación con un valor RII de 0,588 afecta menos el rendimiento del equipo de excavación.

Palabras clave: Aplicación móvil, Calidad, Rendimiento, Excavación, SPSS

## INTRODUCTION

Quality performance is a numerical measurement of the performance of an organization or process assessed through measurement of physical products and statistical sampling of the output of processes. Excavation equipment is important for the successful implementation of civil projects as excavation is one of the first few activities carried on in a construction site therefore, excavation equipment becomes a major capital investment for the construction industry. The performance of such equipment can vary according to various factors ranging from geographical conditions of the site to operators work experience.

Ashraf M. Elazouni et al (1996) evaluated the performance of excavation equipment's in Egypt. Four types of equipment were considered for the study (Bulldozers, Excavators) Earth- moving equipment was selected because equipment is the major resource in earthmoving operations. The performance was studied based on equipment downtime and operator productivity. The downtime ranged from an average of 21% for excavators, 25% for bulldozers, and 11% for off highway trucks. This is mainly attributed to excessive wear and tear maintenance time and supply of spare parts. The average loss of productivity due to operator skill and training was found to be 13%.

Felix N.G et al (2015) studied the relationship between output of excavators and its performance and found out that in the context of excavators, output has often been quantified in terms of the materials handled by machines, e.g., volume of spoil moved per operator-hour. The effect of bucket capacity on excavator productivity was also studied and it was found out to minimize cycle time the operators only filled the bucket up to 80% of its capacity.

Mohamed Abedalal et al (2016) studied the factors affecting equipment productivity infrastructure construction projects in GCC countries. The target group of the study was professionals from the construction industry. A list of 550 building-construction organizations was obtained and professionals from these organizations were selected and interviewed. The study showed that all the three groups-clients, consultants and contractors of participants generally agreed that out of a total of 29 factors the top influencing factors was Lack of experience of operator which had a 83% influence on the equipment's productivity. The age and loyalty of the operator had a 41% effect on the productivity of the equipment. The effect of lack of proper supervision was found to be 81%.

## FACTORS AFFECTING PERFROMANCEOF EXCAVATION EQUIPMENT

The factors affecting quality performance were identified and broadly classified into four main groups.

Site conditions: Site condition means the physical conditions that have an impact on the performance

of equipment at the site and the surrounding area. These include conditions relating to the environment, transportation, handling, etc. Mainly the type of soil, presence of groundwater has an impact on the performance of equipment. Weather conditions also have an impact on the performance of excavation equipment for instance, when working in persistent rain, the excavation job can face challenges like visibility of the operator and maneuverability of the machine. Other factors that affect the performance of equipment at the site include topography of the site, foot traffic near the site of excavation, delay in placing equipment and lack of proper supervision.

**Equipment maintenance:** This category includes factors like routine maintenance of the equipment. Also if the technician hired to perform maintenance on the equipment is not a licensed technician, the maintenance on the equipment done may not be up to proper standards and can lead to failure of the equipment. Improper calibration of parts of the equipment can lead to decreased performance and can ultimately result in the breakdown of the equipment. The cycle time of the equipment also plays a major role in the performance as a longer cycle time can increase the risk of wear and tear on the equipment.

**Equipment operator:** The equipment operator plays an important role in how equipment as the operator is the person that gives the input necessary for the equipment to perform work. The age of the operator handling the equipment also plays an important role in the performance of the equipment as age related complications can hinder the ability of the operator of the equipment to perform the excavation work. An experienced operator is able to perform work more efficiently and identify any problems faster than inexperienced operators. The training received by the operator ensures that the operator knows the function of the equipment and how certain excavation works are performed.

**Economic factors:** Economic considerations such as the cost of owning the equipment and operation and fuel costs are some of the most important factors that play a deciding role in the equipment performance.

## METHODOLOGY

The data was collected by conducting questionnaire surveys to various construction sites. A total of 50 construction sites were visited and various construction professionals including project managers, site engineers and contractors was interviewed. A five-point scale is adopted to facilitate ranking of the factors. The following values were assigned to the respondent's ratings. They were Strongly Disagree-1, Disagree-2, Neutral-3, Agree-4, Strongly Agree-5.

## RELIABILITY CHECK

The reliability of questionnaire was checked using Cronbach's alpha. Cronbach's alpha is reliability coefficient that provides a method for measuring consistency of questionnaires. The equation for Cronbach's alpha coefficient is as follows.

$$\alpha = \frac{K}{K-1} \left[ 1 - \frac{\sum s^2 y}{\sum s^2 x} \right]$$

Where;

$K$  is the number of items

$\sum s^2 y$  is the sum of item variance

$s^2 x$  is the variance of total score.

The alpha coefficient was found to be 0.84 indicating good internal consistency hence data collected is reliable

#### RANKING OF FACTORS

The data obtained from questionnaire survey was ranked. The ranking is done using Relative Importance Index (RII). Relative Importance Index analysis identifies the most important criteria based on participant responses and is also a suitable tool for prioritizing indicators assessed on a Likert scale. The range of RII varies from 0 to 1 with larger number indicating the higher importance to that factor. The equation for RII is as follows

$$RII = \frac{\sum W}{A \times N} \dots \dots \dots (1)$$

Where

$W$  is the weighting given to each factor by the respondents (ranging from 1 to 5)  $A$  is the highest weight (i.e., 5 in this case)  $N$  is the total number of respondents

Table 1: The ranked factors

FACTORS	RII	RANK
Type of soil	0.832	1
Weather condition at site	0.804	2
Work experience of operator	0.800	3
Availability of emergency funds for spare parts	0.760	4
Age of operator	0.744	5
Amount of moisture content in the soil	0.736	6
Training received by the operator	0.736	7
Skill of the operator	0.732	8
Use of licensed/unlicensed technician to perform maintenance	0.724	9
Topography of the site	0.708	10
Lack of routine maintenance	0.708	11
Frequency of breakdowns	0.708	12
The Groundwater level at the site	0.704	13
Weather condition at site	0.696	14
Psychological condition of operator while handling equipment	0.680	15
Lack of proper supervision of work performed	0.676	16
Improper calibration of working parts of the equipment	0.676	17
Cost of acquiring the equipment itself	0.644	18
Age of the equipment	0.636	19
Delay in payment to the contractor	0.612	20
Manufacturing defects in the equipment	0.596	21
Cycle time of the equipment	0.588	22
Foot traffic near site of excavation	0.584	23

## RESULT AND DISCUSSION

The top factors that affect the performance of excavation equipment are as follows. The type of soil was ranked the highest with an RII score of 0.832 indicating that not using the appropriate equipment for the soil type will result in the decrease in performance of the equipment. Weather conditions at the site was ranked second with an RII of 0.804, adverse weather conditions like heavy rain or fog can hinder the working of the equipment and reduce visibility of the operator. The third highest ranked factor is regarding the work experience of the operator, using operators with significant experience increases the productivity of the equipment. Availability emergency fund for spare parts is ranked fourth. The fifth most ranked factor is age of the operator, age related complications can result in the operator not being able to perform work efficiently. The least ranked factor is foot traffic near the site of excavation with RII score of 0.584.

## REFERENCES

- Adhiyaman M., Manikandan M., Pazhani K.C. (2018), A study and analysis of construction equipment management used in construction projects for improving productivity, *International Research Journal of Engineering and Technology*, Vol 5, 1297-1303
- Aminah Robinson Fayek, Nima Gerami Seresht (2018), Dynamic modelling of multifactor construction productivity for equipment intensive activities, *Journal of Construction Engineering and Management*, Vol 144, Issue 9, 1-13.
- Ajibade Ayodeji Aibinu, Argaw Treken Gurmu (2017), Construction Equipment Management practices for improving labour productivity in multistory building construction projects, *Journal of Construction Engineering and Management*, Vol 143, Issue 10, 1-13.
- Arazi Idrus, Mohd. Faris Khamidi, Mohd. Sahir Liew, Waris M. (2014), Criteria for the selection of sustainable onsite construction equipment, *International Journal of sustainable Built Environment*, Vol 3, 96-110.
- Belodedenko S.V., Bilichenko G.M. (2019), Application of risk analysis methods in the maintenance of industrial equipment, *Procedia structural integrity*, Vol 22, 51-58.
- Boseok Choi, Hyunho Jung, Sanghyeok Kang, (2022) Temporal analysis of the frequency of accidents associated with construction equipments, *Safety Science*, vol 153.
- Car-Pusic D, Marovic I, Sopic M, Tijanic K, (2019), Analysis of the Construction Machinery Work Efficiency as a Factor of the Earthworks Sustainability, *International journal of earth and environmental science*.
- Dushyant A. Deshmukh, Parag S. Mahatme (2016), Factors Affecting Performance of Excavating Equipment: An Overview, *International journal of science and research*, vol 5, issue 1.
- John-Paris Pantouvakis, Marina Marinelli (2012), Investigation of earthmoving trucks deterioration using discriminant analysis, *International Journal of Project Organisation and Management*, vol 4, 397-413.
- Kleopatra Petrousatou, Ilias Naskoudakisa (2016), A thematic review of main researches on construction equipment over the recent years, *Procedia Engineering*.
- Mahaboobali Nadaf, Priyanka Methe, Rashmi J.V, Thejaswi K.P. (2018), Identification of factors influencing equipment productivity in construction projects, *International Research Journal of Engineering and*

Sustainability, Agri, Food and Environmental Research, (ISSN:0719-3726), 12(X), 2024:  
<http://dx.doi.org/>

Technology, vol 5, 379- 384.

Niswana. T (2017), study on factors affecting equipment management and its effect on productivity in commercial building construction, International Journal of Advanced Research Trends in Engineering and Technology, Vol. 4, Special Issue 11.

Received: 24<sup>th</sup> March 2023; Accepted: 03<sup>th</sup> August 2023; First distribution: 30<sup>th</sup> October 2023